[redacted] 25X1A

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2 October 1964

MEMORANDUM FOR THE RECORD

SUBJECT: Trip Report to [redacted] 25X1A
to Discuss "Direct (Virtual) Image Viewer

BACKGROUND:

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A presentation and report on Phase I of subcontractor [redacted] was received at a September 24 meeting held at [redacted] facilities in [redacted] and attended by prime contractor [redacted] and subcontractors [redacted] To supplement the decisions resulting from that meeting, the following background is provided:

1. The operational success of the direct (virtual) image viewer, even in prototype, depends almost entirely upon the fabrication of a diffraction grating which, in quality, must exceed the current state-of-the-technology to meet our stringent optical requirements. Feasibility of virtual image viewing has already been proven: a grating with the desired characteristics will make this new mode of viewing practical.

2. The principal objective for the phase grating is to concentrate most of the system's transmitted energy into 13 orders -- that is, the zero order and the six orders on either side. As specifications now read, it is also required that adjacent orders differ no more than 40% in intensity and that the difference between the lowest and highest intensity in the total field not exceed 2:1.

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3. During Phase I of their effort, [redacted] investigated three methods for achieving stipulated grating characteristics. All three methods involve ruling with a diamond tool on metal. Phase I was in a sense a feasibility study, for no practical tests in a system were required. [redacted] approach was to numerically evaluate diffraction integrals for various groove profiles. (Calculations were computer-aided using the FORTRAN II Program). They selected a cylindrical groove form and a groove radius that theoretically will produce multiple orders of reasonably equal intensity. Since their method yields only one-dimensional gratings, two identical gratings will have to be replicated and then crossed to give the 10" x 10" field needed for viewing. [redacted] a recognized authority in the field of optics and gratings, attended the meeting at our request and later expressed his confidence in [redacted]

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theoretical work. Ours and [redacted] main interest now is in the relationship between the theoretical and actual quality of [redacted] test gratings since discrepancies between theory and the craft of grating-making are yet unpredictable). 25X1A 25X1A

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4. [redacted] plans to double-rule their gratings because of the amount of metal (aluminum) to be dislodged by the tool. The possible problems associated with double-ruling are formidable. On the other hand, [redacted] has 25X1A developed groove-measuring facilities which, by [redacted] standards, 25X1A are "impressive." This means that [redacted] possesses the techniques and 25X1A equipment to monitor and evaluate the groove shape they are getting. It would be to our advantage to request [redacted] to supply us with complete data on groove shape and diffraction intensity distribution of the first trial 25X1A grating: the data would indicate the degree of their success.

5. In the execution of its work for another project, the Exploratory Development Laboratory (P&DS) developed a technique which we recently determined can also be applied to making high-quality yet economical phase gratings for the virtual image viewer. [redacted] is capable of making single 25X1A gratings which are two-dimensional, with 11 to 13 fairly evenly illuminated orders emanating from all sides of the central order. The quality of their usefulness has already been demonstrated in a rough laboratory mock-up. Moreover, the technique in comparison to [redacted] is simpler, more 25X1A rapid and far less expensive. At this date experimental gratings made

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by [redacted] without benefit of high-quality glass or suitable Ronchi ruling fall short of specifications on only one small point: fall-off in overall intensity for gratings in the crossed condition is a factor of 5:1 rather than the required 4:1. However, compromise in this area is felt to be trivial. [redacted] has measured the energy distributions of its best experimental gratings. With some minor work involving refinement of processing controls and procurement of a special-characteristic Ronchi ruling (from which the gratings are made), [redacted] gratings would appear to meet the specifications as they now read. 25X1A

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6. [redacted], in fact, believes it cannot meet the specifications on similar points -- but to a greater degree. In their report [redacted] concluded that their best combination of groove shape and radius is "basically capable, in theory, of meeting requirements of the direct viewers." 25X1A

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However, [redacted] at this time cannot meet the specification that energy shifts between adjacent orders are not to exceed 40%. Currently, these shifts approach 70%. It is reasonable to believe that the application will not improve the theory.

7. As a consequence of these shortcomings (in both 5. and 6.), we plan to reappraise original specifications which are now thought to be arbitrary. Tolerable limits of intensity difference across the field as well as from order to order are to be more realistically specified on our part. Modifications in these areas will not, it is felt, compromise quality of viewer performance. A straightforward laboratory test which was 25X1A suggested by [redacted] and can be performed in-house will help us derive more useful data. (It was agreed that overall light intensity for viewing is not a problem at this point).

DISCUSSION:

Results of [redacted] Phase I work were anticipated with two alternative 25X1A courses:

a. If their work showed itself to be compromising or hazardous in direction, we would sever them from the project -- as provided for in their subcontract with [redacted] 25X1A

b. If, on the other hand, we concluded that the work was promising and competitive, they would proceed into the first trial grating (a 2" x 2" format) with a review scheduled at the end of three months time.

25X1A It was the project monitor's opinion that, on the evidence of their preliminary work, [redacted] should be allowed to undertake Phase II, Trial 25X1A Grating I. A meeting will be held with the same attendees at [redacted] 25X1A [redacted] facilities during January 1965. By that time the optical system will be aligned and functioning, so that we can subject [redacted] grating to 25X1A a practical test. Because the first trial will be ruled only once, it is 25X1A foreseeable that [redacted] will have to be allowed to continue into the second trial grating (a two-month effort) before we have grounds for a final, confident decision. The following is a comparative breakdown of [redacted] 25X1A and [redacted] efforts in terms of cost and time. It must be reiterated that 25X1A each effort utilizes a different technique and that both results, to date, are significant. The exact costs and time schedules for [redacted] production 25X1A have already been detailed in the 29 September 1964 memorandum to the Assistant for Plans and Development.

a. TIME: In time alone, production of gratings by [redacted] 25X1A would knock off about 6 months to a year of the main contractor's projected schedule. On that schedule [redacted] progress is the most 25X1A unpredictable and depends not only on the number of test gratings necessary to prove their technique before the master can be undertaken but also on a machining-scheduling problem within their own facilities for the master. If [redacted] meets no obstacles the 25X1A

viewer can be completed in 10 months. With extensions allowed for, the viewer might require more than the maximum 16 months covered by the contract. Thus, a 10" x 10" [redacted] grating would be available in approximately 6 months and could be used immediately by [redacted] and [redacted] for completing and testing the viewer instrument. Even for this use alone, investment in [redacted] gratings would be well justified. If [redacted] were to proceed to the master, it might not be ready for as long as 7 months. If [redacted] contract were to be discontinued before that point, the viewer would be ahead of schedule as afforded by [redacted] 10" x 10" already in use. From that point of view, the insurance provided by [redacted] parallel effort is decidedly worth a modest expenditure.

b. COST: If we proceed to Phase II, Trial II, with [redacted] as well as endorse [redacted]s work for a maximum [redacted] we are still in good financial shape. [redacted]s trial gratings are each approximately [redacted] To allow [redacted] two trials at this cost to certify their technique is sensible: it is the deposition of [redacted] for the [redacted] 10" x 10" master grating -- plus the cost in the future of additional masters and replicates for production viewers -- that is really being considered.

An additional consideration is that of fabricating gratings larger than 10" x 10". The [redacted] is currently limited in size to approximately 12" x 12". On the other hand, [redacted] has the capability of ruling on an 18" x 24" surface and replicating it. Assuming that optical elements can be fabricated to utilize such gratings and that a viewing field of this size would ultimately prove useful, premature termination of [redacted] efforts could subsequently prove embarrassing and possibly disastrous. The [redacted] should be requested to study the problem of producing their gratings in these larger sizes as a pre-requisite to any decision which shuts off [redacted] grating development program.

CONCLUSIONS:

1. A blunt comparison between [redacted] efforts would be naive at this stage. [redacted] has been authorized by the project monitor to continue into Phase II, Trial I, so that we will have practical, real results to evaluate. Their theoretical work looked promising enough to warrant application.

2. [redacted] effort should be strongly encouraged, since their rough, experimental gratings are already very close to specifications. Because

the direct (virtual) image viewer requires a first-rate diffraction grating, we prefer for the time being to exploit both efforts for their potential.

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